TO:       Professor Grady  
FROM:     Calvin Sessions, Jonathan Law, and Chris Wittmier  
DATE:     October 13, 2004  
SUBJECT:  Project Plan - Digital Caliper Design

Introduction
The purpose of this document is to introduce and outline our instrumentation design team project plan. This document will provide a description regarding the design and construction of a digital caliper. A general objective and project purpose will first be described, followed by a functional and general hardware description and testing procedures. Then a general cost analysis for parts and material will be touched upon. Finally, this document will address the distribution of work with an attached working calendar.

Project Purpose
At the macro level, the overall objective of this team project is to gain research and design experience while further developing and enhancing cooperative teamwork skills. This project will allow our members to step through the actual design process procedure including concept development, design, and construction.

The purpose of the digital caliper would be to measure the dimensions of small objects, electronically eliminating human error generated from analog/mechanical calipers or other measuring tools. The design will be portable, inexpensive, and perform with accurate precision. Its use would be best suited for a laboratory environment; therefore it is appropriate that our design utilizes standard SI units. The desired range for our digital caliper design will be 30 cm.
Functional Description

As shown in Figure 1, the digital caliper design, like a typical analog caliper, will have two arms used to measure distance, thickness, or diameter. One arm will be mounted securely on a base to serve as a reference point and the other arm will be adjustable. The adjustable arm will slide on a track with respect to the variable distance up to 30 cm.

![Figure 1: Digital Caliper Design](image)

Our digital caliper design will differ from conventional digital calipers sold in the market. Instead of using some type of mechanical sensor or slug, we will utilize optics to gather distance measuring data. There are a number of distance measuring sensor packages available that can be implemented as both the light source and phototransducer. With the range finding device, an emitted beam of light will reflect off of a mirror attached to the adjustable caliper arm. The beam of light will then be detected by the built-in photo sensor on the device. This method of distance measuring will be further developed later in the hardware description.

The base of the digital caliper with the attached reference arm will house the electronic system. The system will include the transducer, battery power supply, signal processing and A/D circuitry. The information will then be outputted using a 7 segment LED display, expressing the measurement units in millimeters.
General Hardware Description

Figure 2 displays a general block diagram for the digital caliper design. This section of the document will layout general hardware elements that will be required in the design.

As discussed in the functional description, a distance measuring device will be utilized to optically record data. The most favorable device that we would like to use is the Sharp GP2D12 distance measuring sensor. This range finder contains both the infra-red LED light source and photodector.

According to the Robotic Society of Southern California (RSSC) website, light is emitted from the infra-red LED through a lens which focuses the beam on a small spot of the measured object. The light then reflects off of the object to the position sensitive device (PSD), as shown in Figure 3. This is referred to as the optical triangulation principal. Also stated on the RSSC website, as the distance to the sensed object changes, the spot of light moves on the position-sensitive detector, and a different distance is reported.
Figure 4 displays the dimensions of the Sharp GP2D12 distance measuring sensor. This information was obtained from the GPD12 data sheet and manufacturer website. Note that the sensor only requires a 5 volt source. The output signal produces a voltage with respect to the distance of the object.

**Figure 4: GP2D12 Distance Measuring Sensor Dimensions**

The signal processing aspect of the digital caliper design was originally going to be performed by implementing a microcontroller. However, this method would eliminate the learning process involved with instrumentation design. To obtain further research and design experience, we will use the GP2D12, which output an analog signal. This signal, however, as apparent in the Figure 6, generates a nonlinear curve. The biggest task in the signal processing design is the linearization and amplification of the output. This will be further studied, during the research and development process.
The analog signal will then be transformed utilizing an A/D converter. The digital signal will be displayed using 7 segment LED displays. Because our range is to 30 cm and we are using millimeters as a unit of measurement with accuracy up to a millimeter, three displays will be necessary as shown in Figure 5. This output display will be mounted on the system. To save time, we will only display the units in millimeters, but if time permits, unit conversion will be an option.

Because we would like this instrument to be portable, the digital caliper will be powered by a battery. It would be desirable to solder the components onto circuit boards to not only refine and practice assembly skills necessary for prototyping, but to allow the design to look professional.
General Cost Analysis
After performing some general cost analysis research, we have come to the conclusion that the most expensive, yet critical item involved in this design is the Sharp GP2D12 distance measuring sensor. Our team found this device from a distributor website for $12.50 plus shipping and handling.

We would also like to utilize a used and/or inexpensive analog caliper to eliminate extra time and energy to have the caliper arms and track machined or manufactured. A caliper will be purchased through EBAY utilizing a budget under $10.

The rest of the circuitry components will be found in the EET laboratory. If a box for the system housing is not found, we will request for a machined metal housing from the MET majors for a small fee. Any additional circuitry components not available in the laboratory will be ordered. Therefore our project price range will be about $30, allowing nobody in the group to be required to contribute no more than $10 each.

Testing and Calibration
There are procedures for testing and calibration of the sensor unit in the manufacture’s data sheet. Before the distance measuring sensor is connected to the system, we will follow the proper guidelines and procedures to calibrate the unit.

According to the distance measuring sensor data sheet, the device has a limited working range. The minimum working range will be compensated by offsetting the device on the digital caliper system. A standard block with a specified length will be used as the control for the calibration process. Perhaps we can obtain a standard block from the manufacturing lab in the Engineering Technology Building.

We will allocate a minimum of two weeks for total system testing and calibration. The first week will of the two will allow us to perform our alpha testing and the second week should yield a final product.
**Distribution of Work**

Though all of the team members will be responsible for the entire project and involved with every aspect, each member will manage and become experts in the following specific tasks:

<table>
<thead>
<tr>
<th>Team Members</th>
<th>Job Descriptions</th>
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<tbody>
<tr>
<td>Calvin A. Sessions</td>
<td>Project Manager&lt;br&gt;-Oversee design and production&lt;br&gt;-Assembly and Testing/Calibration</td>
</tr>
<tr>
<td>Jonathan Law</td>
<td>Signal Processing Design Manager&lt;br&gt;-Linearization of analog transducer signal&lt;br&gt;-Amplification of signal for higher resolution</td>
</tr>
<tr>
<td>Chris Wittmier</td>
<td>Output Design Manager&lt;br&gt;-Design method for A/D conversion&lt;br&gt;-Translating digital output signal into desired measuring unit output</td>
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**Calendar**

<table>
<thead>
<tr>
<th>Week 1</th>
<th>Oct. 11 – 17</th>
<th>-Project Plan/Oral Presentation&lt;br&gt;-Order Parts</th>
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<tbody>
<tr>
<td>Week 2</td>
<td>Oct. 18 – 24</td>
<td>-Initial R/D&lt;br&gt;-Parts gathering</td>
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<tr>
<td>Week 4</td>
<td>Nov. 1 – 7</td>
<td>-Development</td>
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<tr>
<td>Week 5</td>
<td>Nov. 8 – 14</td>
<td>-Development&lt;br&gt;-Signal Processing Completed by mid-week&lt;br&gt;-Build Complete System</td>
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<tr>
<td>Week 6</td>
<td>Nov. 15 – 21</td>
<td>-Calibration/Testing of System</td>
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<td>Week 7</td>
<td>Nov. 22 – 26</td>
<td>-Refinement</td>
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<tr>
<td>Week 8</td>
<td>Nov. 27 – Dec 5</td>
<td>-Finished Product&lt;br&gt;-Project Presentations</td>
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**Conclusion**

Our instrumentation design team is designing and constructing a digital caliper using optical distance measuring sensor. The design will be used for laboratory purposes and measure distance, thickness, and diameter in millimeter units. The working distance range will be from 0 cm to 30 cm.

This project will allow our team members to have research and design experience in a cooperative team environment, while learning instrumentation methods.